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THE UNIFICATION OF THE CIVIL AND ASTRONOMICAL TIME SYSTEMS.

Present tendencies are clearly toward the unification of systems and units employed in civil and commercial life as well as in the world of science. A case in illustration is the proposal to have the astronomical day begin at midnight, instead of at noon, as it now does, and thus conform with the universal practice in civil life. The Astronomer Royal of England, Sir F. W. Dyson, and the Director of the University Observatory, Oxford, Professor H. H. Turner, have proposed the question for discussion by correspondence, or otherwise, with a view to presenting the expressions of opinion at a future meeting of the Royal Astronomical Society. The subject is an old one and its history* is not only interesting but conveys a valuable impression as to whether it is a matter of importance or of comparative indifference that the change be made or be not made.

The great French astronomer, Laplace, proposed to the Bureau of Longitudes of the French government in 1804 that the astronomical day be made to coincide with the civil day, that is by beginning the day at midnight. The proposal was adopted, and Laplace in his "Mécanique Celeste" and other publications made use of the new system. However, the "Connaissance des Temps," corresponding to the American Ephemeris and Nautical Almanac, tho the work of the Bureau of Longitudes, never made the change. Some individual astronomers followed Laplace's example, but Leverrier carried French practice back to the old system.

The International Congress which met at Washington in 1884, the year in which our country was divided into Standard Time zones, adopted the following resolution:

"That the conference expresses the hope that, as soon as may be practicable, the astronomical and nautical days will be arranged everywhere to begin at mean midnight."

The Astronomical Congress which met in Geneva in 1885 discussed the subject, but in view of the strong opposition of many leading astronomers in various countries the subject was not pressed to a conclusion.

Early in the 1890's the Canadian Institute and The Astronomical Society of Toronto appointed a commission to report anew upon

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*Supplied by Poincaré's paper reprinted in *The Observatory* for September, 1917.

the question. The correspondence instituted led to the receipt of 108 replies in favor of the change and 68 replies opposed to it. The British Admiralty—as affecting navigation—was of the opinion that the proposed change would be advantageous, but only on condition that it should be adopted simultaneously in the nautical almanacs of all the leading countries. The Minister of Public Instruction in France, in 1894, requested the Bureau of Longitudes to reëxamine the question and to submit a report. The following resolutions were adopted in 1895:

"The Bureau of Longitudes is in agreement, in principle, with the reform proposed by the Canadian Institute for the change of the commencement of the astronomical day.

"The Bureau is of the opinion that this reform, as the Lords of the Admiralty have observed, can only be of value provided that the governments publishing the principal ephemerides are in agreement over the proposed change.

"That, in view of the fact that the unification will only be truly complete when civil time is counted—as in Italy—from 0 to 24 hours, the Bureau expresses the desire that this latter reform should also be adopted as soon as possible."

The subject appears to have lain dormant during the succeeding twenty-two years. Whether this may be taken as an indication that the proposed change is not vital or important, or merely that the chances for favorable action were considered unpromising, does not appear, but that both factors have influenced in favor of inaction is probably a fair compromise with the truth.

The subject is not one which concerns the public except as it relates to the safety of travel at sea. It interests the higher officers of ships, explorers, surveyors and astronomers; in brief, those who are dealing with astronomical data technically and professionally. It may be said that astronomers in general are satisfied with, and prefer the present system. The preferences of ships' officers have apparently not been expressed to any extent, and the data for predicting their point of view seem to be lacking, with few exceptions. I suppose there are several hundred times as many ships' officers, with duties relating in part to the determination of their latitudes, longitudes and times, as there are astronomers. If the mariners are in reasonable unanimity for the change it would seem that the change should be made; at least a sincere and earnest effort should be made to comply with their wishes and requirements. If the mariners in substantial majority are opposed to the change it would seem, likewise, that the change should not be made. We should not overlook the fact that the tens of thousands of ships' captains and their officers have learned the astronomical part of their profession on the basis of the existing system. It is safe to predict that a majority of these have been instructed in, and have learned, the astronomical practice almost wholly by rote or rule of thumb and not upon the basis of deduction and understanding why. These facts being undoubted, have we reason to believe that the trained mariners now in service will welcome the change? Will it be easy for them to unlearn the existing system and learn a new system? Would the shipping of the world while the process of change is under way be free from the element of risk and danger?

Until the shipping world has canvassed the question and expressed itself for or against the change, those who have the duty of preparing nautical almanac data for the use of sailors and others could not wisely decide to make the change.

One of my colleagues has made the valued suggestion that even tho the marine service favor the change unanimously or otherwise, that is not a sufficient reason why the astronomers should change. It is the practice, at least in America and American shipping, for the astronomers to use one edition of the American Ephemeris and Nautical Almanac and for the marine service to use another edition less comprehensive. It would be very easy, and comparatively inexpensive, for the Superintendent of the Nautical Almanac to prepare the marine edition on the basis of the day beginning at midnight. The mariner would not be concerned with the fact that the astronomer's day begins at noon. Relatively few astronomers would need to know that the mariner's day begins at midnight.

Overlooking the fact that mariners are already trained in the old system, it does not seem clear that the proposed civil system would be an advantage in all respects. The mariner, so far as I am familiar with prevailing practice, places his chief dependence for latitude upon noon observations of the Sun, and he works both ways from the meridian in his time determinations. It is certainly more convenient for mariners in the Atlantic Ocean, the Mediterranean and the western Indian Ocean to have their data in the almanac tabulated for Greenwich noon rather than for midnight: the intervals for interpolation in the almanac tables will, in general, be smaller. This objection could be met or prevented, of course, by publishing the data for the noon epoch, as at present, even though the mariner's day begin at midnight.

There are clearly several advantages to the mariner in the proposed change. His log book and his dealings with port officials are recorded in civil time, whereas his sailing data, in so far as they are based upon observations of celestial bodies, are in astronomical time. He is required to deal simultaneously with both kinds of time, with danger of confusion. For example, if he is due to reach port at 11:30 A. M. of July 4, his time sight at eight o'clock that morning would be made at the approximate astronomical time, July 3, 20 hours. It is undoubtedly true that the mariner's training in many details of his profession would be simpler if, *de novo*, he could be instructed on the basis of the proposed new system.

Coming to the astronomical side of the question, it seems difficult to justify the change. There are observers of the Sun, but they are few in number and the precise or accurate times of observations concern them relatively very little. In the very great majority of cases the astronomer's deeds are "deeds of darkness." His observations relate to the night sky. It is a convenience to have his work of any given night, of the whole of the night, or of any part of the night, fall within one and the same day whose numerical description is never in doubt. The prevailing system provides for this in an easy and natural way. The adoption of the civil system would assign his work on one night, if it lay on both sides of midnight, to two different days of the month. He would quickly adapt himself to the requirements of the new system, and if that were the only objection it might, in my opinion, be overlooked and neglected. A more serious objection, it seems to me, lies in the fact that the astronomer's computations relating to hour angle, azimuth, zenith distance, etc., have their natural starting point at the meridian, the upper meridian and not the lower meridian. Astronomical time conveniently defines itself as an hour angle; that is, the angular distance measured westward from the meridian. Mean time is the hour angle of the mean Sun, apparent time is the hour angle of the true Sun, sidereal time is the hour angle of the vernal equinox. If mean and apparent times are to be reckoned from midnight, the existing formulae will not fit the new coördinates; and, besides, as all observations of the Sun are made when the Sun is above the meridian it is more convenient to have the formulae and the data refer to upper meridian passage as origin. It will not be convenient, certainly, to reckon sidereal time from lower meridian passage. Shall we reckon mean and apparent time from the lower meridian passage and sidereal time from upper meridian passage? The confusion in formulae and transformations would be unfortunate, to say the least.

A serious objection to the proposed change relates to the discontinuity introduced into astronomical records. Observations made before the epoch of the proposed change are expressed in Julian days beginning at noon. Observations made after the epoch of the change would be expressed in Julian days beginning at midnight. The old and the new observations would be out of step by one half day; a half step that would always have to be taken into account. This would threaten to be a fruitful source of inconvenience and error. Just how troublesome this would prove to be is uncertain as we have no experience to guide. The change to the Gregorian calendar, in 1582 in Catholic countries, in 1752 in England, and at other dates elsewhere, has not been especially inconvenient to astronomers—it has to historians—because the "step" involved a whole number of days and the Julian-day system easily takes such things into account. In fact, astronomers seldom have occasion to recall the Gregorian discontinuity, tho this is partly because astronomical observations before the Gregorian epoch were relatively few. The proposed change here discussed would, I think, bring forcibly to our notice that an enormous number of observations were made between Gregory's time and our day!

It goes without saying that the proposed change should not be consummated in any one country alone. It should rest upon the concurrence of all the leading nations, or not be made at all. If an international conference, or other organization commensurate with the importance of the problem, is called together to consider the question, the proposal to count the hours of the day continuously from 0 to 24 hours should be discussed and disposed of at the same time. An effort should likewise be made to reform the Greek Church calendar, now prevailing in Russia. It is obviously important that changes in time systems should be as few as possible. The human race is fortunate that no changes have occurred since the days of Gregory except as to questions more or less local and temporary, such as the adoption of Standard Time zones and daylight saving.